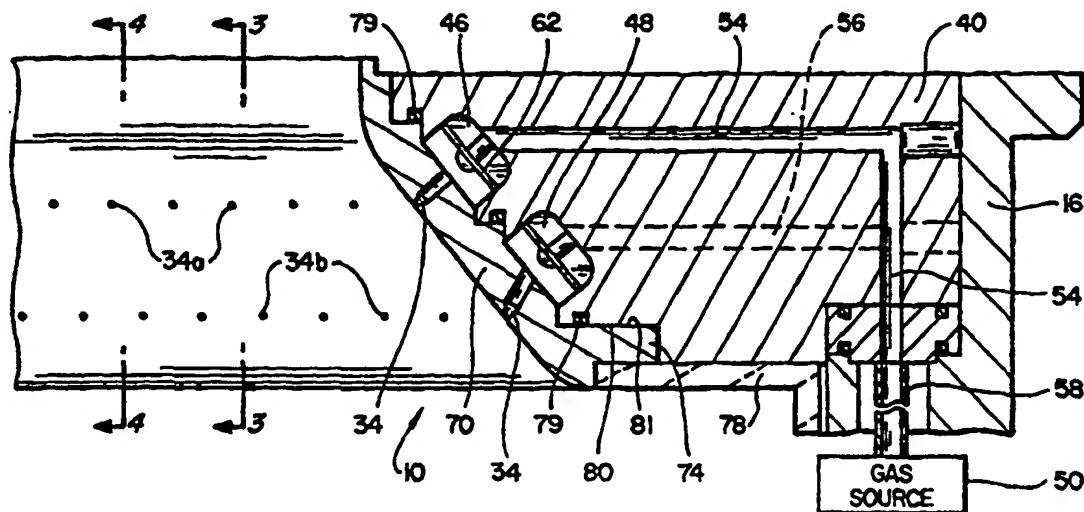




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : C23C 16/00	A1	(11) International Publication Number: WO 97/03223 (43) International Publication Date: 30 January 1997 (30.01.97)
<p>(21) International Application Number: PCT/US96/10657</p> <p>(22) International Filing Date: 21 June 1996 (21.06.96)</p> <p>(30) Priority Data: 08/499,861 10 July 1995 (10.07.95) US</p> <p>(71) Applicant: WATKINS JOHNSON COMPANY [US/US]; 3333 Hillview Avenue, Palo Alto, CA 94304-1223 (US).</p> <p>(72) Inventors: NITESCU, Petru, N.; 687 Berkshire Place, Milpitas, CA 95035 (US). MATTHIESEN, Richard, H.; 140 Spreading Oak Drive, Scotts Valley, CA 95066 (US).</p> <p>(74) Agents: TEST, Aldo, J. et al.; Flehr, Hohbach, Test, Albritton & Herbert, Suite 3400, 4 Embarcadero Center, San Francisco, CA 94111-4187 (US).</p>	<p>(81) Designated States: CN, JP, KR, SG, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).</p> <p>Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>	

(54) Title: GAS DISTRIBUTION APPARATUS



(57) Abstract

A gas distribution apparatus (10) for delivering a gaseous substance to a chamber (12) for processing semiconductor wafers (22). The apparatus (10) includes at least one plenum (46, 48) formed for receiving a gaseous substance, a plenum body (40) mountable to the chamber (12) and having at least one conduit (54, 56) formed therein and a nozzle structure (70) removably mounted to the plenum body (40). The conduit (54, 56) is coupled to the plenum (46, 48) for delivery of the gaseous substance to the plenum (46, 48) and the nozzle structure (70) has a plurality of nozzles (34) coupled to the plenum (40) and configured for injection of the gaseous substance into the chamber (12).

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	GB	United Kingdom	MW	Malawi
AT	Austria	GE	Georgia	MX	Mexico
AU	Australia	GN	Guinea	NE	Niger
BB	Barbados	GR	Greece	NL	Netherlands
BE	Belgium	HU	Hungary	NO	Norway
BF	Burkina Faso	IE	Ireland	NZ	New Zealand
BG	Bulgaria	IT	Italy	PL	Poland
BJ	Benin	JP	Japan	PT	Portugal
BR	Brazil	KE	Kenya	RO	Romania
BY	Belarus	KG	Kyrgyzstan	RU	Russian Federation
CA	Canada	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic	KR	Republic of Korea	SE	Sweden
CG	Congo	KZ	Kazakhstan	SG	Singapore
CH	Switzerland	LI	Liechtenstein	SI	Slovenia
CI	Côte d'Ivoire	LK	Sri Lanka	SK	Slovakia
CM	Cameroon	LR	Liberia	SN	Senegal
CN	China	LT	Lithuania	SZ	Swaziland
CS	Czechoslovakia	LU	Luxembourg	TD	Chad
CZ	Czech Republic	LV	Latvia	TG	Togo
DE	Germany	MC	Monaco	TJ	Tajikistan
DK	Denmark	MD	Republic of Moldova	TT	Trinidad and Tobago
EE	Estonia	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	UG	Uganda
FI	Finland	MN	Mongolia	US	United States of America
FR	France	MR	Mauritania	UZ	Uzbekistan
GA	Gabon			VN	Viet Nam

GAS DISTRIBUTION APPARATUS

BRIEF DESCRIPTION OF THE INVENTION

This invention relates in general to system for distributing gaseous substances and, more particularly, to a gas distribution ring for semiconductor wafer processing systems.

BACKGROUND OF THE INVENTION

5 The processing of semiconductor wafers is typically accomplished by positioning the wafer in a chamber and subjecting the surface of the wafer to various chemical substances. The chemistry of the substances depends upon the type of processing employed as well as the nature of the devices formed on the surface of the semiconductor
10 wafer. The chemical substances are generally delivered to the chamber either in gaseous form or with a carrier gas. With some processes, the formation of the film layers on the wafer surface is enhanced using high density plasma.

Various systems have been used to deliver the gaseous substances to the processing chamber. One type of gas delivery system employs a stainless steel ring vertically spaced
15 above the exposed surface of the wafer. The gaseous substance flows through nozzles mounted to the ring and into the processing chamber toward the wafer surface. Another type of device includes a manifold which extends across the wafer surface. The manifold has a plurality of nozzles or holes for showering the wafer with the gaseous substances required for the chemical process.

20 Repair and maintenance of the available gas delivery devices is typically a labor intensive and time consuming process. The device must be disassembled to adequately clean the nozzle holes and interior plenums, interrupting the process for an extended period of time and significantly reducing the efficiency and output of the processing system. The nozzles with devices such as the gas distribution ring may not be removed
25 or replaced because they are an integral component of the device. A gas distribution system which may be efficiently repaired and maintained without significantly interrupting the processing operation is desirable.

OBJECTS AND SUMMARY OF THE INVENTION

It is a primary object of this invention to provide a gas distribution apparatus for injecting gaseous substances into a processing chamber.

5 It is a further object of the invention to provide a gas distribution apparatus which provides a substantially uniform distribution of gas across the surface of a wafer.

It is another object of the invention to provide a gas distribution system in which the nozzles may be efficiently and conveniently replaced.

10 A more general object of the invention is to provide a gas distribution apparatus which may be economically manufactured and easily installed in a processing chamber, and which may be conveniently and efficiently repaired and maintained.

15 In summary, this invention provides a gas distribution apparatus which is particularly suitable for delivering a gaseous substance to a processing chamber. The apparatus generally includes a plenum body mountable to the chamber, a replaceable nozzle structure removably mounted to the plenum body and at least one plenum formed for receiving a gaseous substance. The plenum body is formed with at least one conduit which is coupled to the plenum for delivery of the gaseous substance to the plenum. The nozzle structure has a plurality of nozzles coupled to the plenum and configured for injecting the gaseous substance from the plenum to the chamber.

20 Additional objects and features of the invention will be more readily apparent from the following detailed description and appended claims when taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

25 Figure 1 is a schematic perspective view, partially broken away, of a gas distribution apparatus in accordance with this invention, shown installed in a plasma-enhanced chemical vapor deposition system.

Figure 2 is a front plan view, partially broken away, of the gas distribution apparatus of Figure 1.

Figure 3 is a cross-sectional view taken along line 3-3 of Figure 2.

Figure 4 is a cross-sectional view taken along line 4-4 of Figure 2.

30 Figure 5 is a cross-sectional of a gas distribution apparatus in accordance with another embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Reference will now be made in detail to the preferred embodiment of the invention, which is illustrated in the accompanying figures. Turning now to the drawings, wherein like components are designated by like reference numerals throughout the various figures, attention is directed to Figure 1.

Figure 1 shows a gas distribution apparatus 10 which is particularly suitable for delivering a gaseous substance to a chamber 12 of processing system 14. Processing system 14 is used for plasma-enhanced chemical vapor deposition processing, although it is to be understood that the apparatus 10 may also be used with other processes on the wafer including, but not limited to, chemical vapor deposition, etching, high temperature film deposition, and the like. Processing system 14 generally includes a chamber wall 16 and a top plate 18 enclosing the chamber 12. A support assembly 20 supports a wafer 22 within the chamber 12 for processing. In the preferred embodiment, the support assembly 20 is an electrostatic clamp assembly of the type disclosed in co-pending application Serial No. (Flehr, Hohbach, Test, Albritton & Herbert File No. A-62195/AJT/JEM), the disclosure of which is incorporated herein by reference. However, other types of support systems such as a mechanical clamping chuck may be used if desired. A plasma source 24 mounted to the top plate 18 and substantially axially aligned with the wafer 22 generates a supply of plasma for enhancing the processing of the wafer 22. Plasma source 24 is described in detail in co-pending application Serial No. (Flehr, Hohbach, Test, Albritton & Herbert File No. A-62268/AJT), the disclosure of which is incorporated herein by reference.

Gas distribution apparatus 10 is mounted to the chamber wall 16 below the top plate 18. In the present embodiment, the distribution apparatus has an annular configuration with the outer peripheral surface 30 of the apparatus being mounted to the chamber wall and the inner surface 32 defining a central opening which extends through the distribution apparatus. A plurality of nozzles 34 inject gas into the processing chamber, with the gaseous substances traveling inwardly from the distribution apparatus toward the central axis of the chamber. The annular configuration of the gas distribution apparatus uniformly distributes the gases around the circumference of the chamber while providing a passageway between the plasma source 24 and the wafer 22. Separating the distribution apparatus 10 from the flow of plasma also provides for independent control over the

plasma density and the flow of the gaseous substances. As is indicated by the arrows in Figure 1, the plasma generated by the source 24 and the active species of the gaseous substance move downwardly onto the wafer surface in the RF field created between the distribution apparatus 10, chamber wall 16 and the support system 20, depositing a layer of film on the wafer.

Although the annular configuration of gas distribution apparatus 10 is preferred, it is to be understood that other configurations are within the scope of the invention. For example, the distribution apparatus may have a rectangular or oval configuration if desired. Instead of one apparatus which extends continuously around the circumference of the chamber, one or more arcuate distribution devices may be employed if desired.

Gas distribution apparatus 10 is of particular advantage in high-density, plasma enhanced processing because of the effects on the gas flow of factors such as the high density of the plasma, the low pressure of the processing chamber (less than 3-4 mTorr for high density plasma enhanced processes compared to more than 100 mTorr for conventional plasma-enhanced systems), and the relatively high energy of the electrons. Because of the lower chamber pressure, the gaseous substances are moved by convection flow rather than free molecular flow.

Turning to Figures 2-4, the gas distribution apparatus 10 will be described in greater detail. Distribution apparatus 10 generally includes a plenum body 40 mounted to the wall 16 of the chamber 12. In the present embodiment, the plenum body 40 is supported on a horizontally-extending ledge 42 of the chamber wall 12. Threaded fasteners 44 distributed around the circumference of the plenum body extend through bores 45 formed in the plenum body and engage the chamber wall 16 to secure the plenum body to the chamber. The top plate 18 covers the plenum body and is secured to the chamber wall 16 as is known in the art. As is shown in Figure 1, the plenum body 40 is positioned immediately beneath the top plate 18 in the present embodiment, although it should be understood that the location of the plenum body is subject to considerable variation depending upon such factors as the design of the chamber 12, the type of processing employed and the nozzle design.

Plenum body 40 has two parallel, circumferentially extending channels 46 and 48 formed in the plenum body. The channels 46 and 48 partially define a pair of plenums for receiving the gaseous substances employed in the processing of the wafer. Channels

46 and 48 are each connected to a gas source 50, 52 through separate conduits 54 and 56 formed in the plenum body 40. For high density, plasma-enhanced chemical vapor deposition one channel is coupled to a source of oxygen and the other to a source of argon and silane. However, various other gaseous substances may be employed depending upon the processing employed in chamber 12. As is shown in Figures 2 and 3, the conduits 54 and 56 are L-shaped, extending outwardly and then downwardly through the plenum body 40 to intersect vertical supply lines 58 and 60 extending through the chamber wall 16. Conduits 54 and 56 are therefore circumferentially spaced around the plenum body 40. In other modifications of the inventions, the conduits may have other configurations and supply lines 58 and 60 may be replaced with lines which extend horizontally through the chamber wall 16.

In the present embodiment, plenum body 40 includes only one conduit for each channel although more than one conduit may be employed if desired. In other modifications of the invention, plenum body 40 may include two or more conduits evenly spaced about the circumference of the plenum body and oriented to tangentially inject the gaseous substance into the plenum with the gaseous substance from each plenum flowing through the channel in the same direction. Tangentially injecting the gaseous substance offers the advantage of improving the tangential uniformity of the surface profile because of the improved distribution of gas within the plenum.

A baffle 62 formed with a plurality of openings (not shown) is mounted in each channel 46 and 48 as is known in the art. Baffles 62 interrupt the flow of gas from the conduits 54 and 56 to the directly-adjacent nozzles 34 to diffuse the gas and more uniformly distribute the flow of gas around the circumference of the plenum body 40. The configuration of the baffles 62 is selected to provide an optimum distribution of gas and is subject to considerable variation. Moreover, the baffle 62 may be omitted if desired.

A nozzle structure 70 is removably mounted to the plenum body 40, covering the channels 46 and 48 enclosing the plenums. The nozzle structure includes a plurality of first nozzles 34a substantially aligned with the channel 46 and a plurality of second nozzles 34b aligned with the channel 48 for injecting the gaseous substances retained in the plenums into the processing chamber. In the illustrated embodiment, the nozzles are integrally formed with the nozzle structure 70 by machining or other suitable means. In

other modifications of the invention, the nozzles may be mounted to the nozzle structure separately using threads, snap-fittings or other suitable securement means. The size, shape, spacing, angle and orientation of the nozzles is subject to considerable variation. In the present embodiment, the nozzles are uniformly spaced around the circumference of the nozzle structure 70, although if required the spacing may be varied to provide a more uniform distribution of gas. The nozzles are preferably configured to provide the layers formed on the wafer surface with a substantially flat profile. As is shown in Figure 2, the nozzles 34 are oriented at an angle in the range of 30° to 90° relative to the wafer plane. However, the nozzles may be oriented at other angles depending on the vertical distance separating the nozzle structure 70 and the wafer 22 and the desired deposition profile on the wafer.

As is shown in Figures 2 and 4, nozzle structure 70 includes an annular flange 74 for mounting the nozzle structure to the plenum body. A plurality of fasteners 76 engage the flange 74 and the plenum body 40 to securely mount the nozzle structure to the plenum body. A protective liner 78 formed of quartz or another suitable material extends across the annular flange 74 and plenum body to isolate the fastener 76 and the plenum body from the interior of the processing chamber. Seal rings 79 are compressed between the nozzle structure 70 and the plenum body 40 to isolate the plenums and prevent gas leakage between the plenums and between the plenums and the chamber 12. The seal rings are formed of a suitable material resistant to high temperatures such as Kalrez or Chemraz, but Viton O-rings may also be employed for lower temperature processes.

The nozzle structure 70 may be conveniently removed from the plenum body by disengaging the fasteners 76 from the plenum body. Removing nozzle structure 70 facilitates cleaning and maintenance of the gas distribution apparatus 10. If desired, a second nozzle structure may be mounted to the plenum body 40 while the first is cleaned, allowing the wafer processing to continue without an expensive and time consuming delay. The second nozzle structure may have an entirely different nozzle configuration than the first if desired. The ability to conveniently remove the nozzle structure 70 improves the efficiency of the repair and maintenance of the gas distribution apparatus 10 and offers considerable flexibility in tailoring the nozzle design to a specific processing application.

When the distribution apparatus 10 is used with a plasma enhanced process as in the present embodiment, the nozzle structure 70 is exposed to a high potential RF energy field. As a result, gas distribution apparatus 10 is preferably grounded unless the nozzle structure 70 is formed of a dielectric material. Plenum body 40 and nozzle structure 70 include mating surfaces 80 and 81 which are formed to maximize the surface contact between the plenum body 40 and the nozzle structure 70 to couple the nozzle structure 70 to ground. The mating surfaces 80 and 81 are preferably plated with a suitable material such as nickel to enhance the surface-to-surface contact. The mating surfaces 80 and 81 also provide a return path for the RF current when the support assembly 20 applies an RF bias to the wafer. In other modifications of the invention, the junctures between the plenum body 40 and the nozzle structure 70 and the chamber wall 16 may be lined with a suitable dielectric material.

In the embodiment shown in the figures, the nozzle structure 70 is positioned radially inwardly of the plenum body 40. However, in other modifications the nozzle structure 70 may have other orientations relative to the plenum body. Moreover, the nozzle structure may be configured so that the injection points of the nozzles 34 are spaced a greater distance from the plenum body than is shown in Figures 2 and 3. The orientation and position of the nozzles relative to the wafer is subject to considerable variation within the scope of the present invention.

Figure 5 shows another embodiment of a gas distribution apparatus 100 in accordance with the present invention. The distribution apparatus 100 includes a plenum body 102 formed with three circumferentially extending channels 104 each defining a separate plenum for receiving a gaseous substance. Each channel 104 is coupled to a separate horizontally-extending conduit 105 formed in the plenum body 102 for joining the channel 104 to a gas source (not shown). As is shown in Figure 5, the conduits 54 and 56 may be vertically aligned since the downward extending stretch of the uppermost conduit is omitted. The channels are enclosed by a nozzle structure 106 which includes a plurality of nozzles 108 associated with each channel 104 for injecting gaseous substances from the plenums into the chamber. As with the previously-described embodiment, the configuration of the nozzle structure 106 and the type, shape, size, number and spacing of nozzles 108 is subject to considerable variation within the scope of the invention.

With the embodiment shown in Figure 5, gas distribution apparatus 100 may be used to inject the same substance at two different flow rates. For example, one plenum may be coupled to a source of oxygen and the other two plenums may be coupled to source of argon and silane. The nozzles 108 may be arranged so that the nozzles of one of the two plenums are oriented to deliver the gaseous substance to the outer areas of the wafer and the nozzles of the other plenum are oriented to deliver the gaseous substance to the center areas of the wafer. The different nozzle orientations which provide different surface profiles which, when combined, result in a substantially flat deposition across the wafer surface. The gas distribution apparatus 100 also may be used to separately inject three different gaseous substances into the processing chamber or, if desired, one of the plenums may be sealed using a suitable capping device if only two plenums are required for a particular process.

Nozzle structure 106 is removably mounted to the plenum body 102 by a clamping device 110. Clamping device 110 includes a clamping plate 112 extending across the plenum body 102 and the outwardly extending flange 114 of the nozzle structure 106. A fastener 116 engages the clamping plate 112 and the plenum body 102 to removably secure the clamping device 110 and the nozzle structure to the plenum body 102. A compliant spacing element 118 is preferably positioned between the clamping device 110 and the nozzle structure 106. A liner 120 formed of a suitable material such as quartz covers the clamping device and plenum body. The clamping device 110 is particularly suitable for use with nozzle structures 106 which are formed of brittle materials such as ceramic materials and quartz.

The plenum body 40 or 102 is preferably formed of aluminum or another suitable metal. The nozzle structure may be formed of a metal such as aluminum or a dielectric material such as a ceramic material, quartz or other dielectric material. The clamping device 110 is preferably formed of a metal such as aluminum, while the fasteners 76 or 116 and 44 are preferably formed of stainless steel.

The foregoing descriptions of specific embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teaching. The embodiments were chosen and described in order to best explain the principles of the

invention and its practical application, to thereby enable others skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the Claims appended hereto and their equivalents.

WHAT IS CLAIMED IS:

1. A gas distribution apparatus for delivering a gaseous substance to a chamber comprising:

5 at least one plenum formed for receiving a gaseous substance,
 a plenum body mountable to said chamber and having at least one conduit formed therein, said conduit being coupled to said plenum for delivery of said gaseous substance to said plenum; and

10 a nozzle structure removably mounted to said plenum body, said nozzle structure having a plurality of nozzles coupled to said plenum and configured for injection of said gaseous substance from said plenum to said chamber.

15 2. The gas distribution apparatus of Claim 1 in which said chamber includes a chamber wall having a top portion, a bottom portion and a side portion joining said top and bottom portions, and in which said plenum body is mountable to said side portion of said chamber wall.

20 3. The gas distribution apparatus of Claim 1 in which said plenum body has an outer surface defining a periphery of said plenum body and an inner surface defining a central opening extending through said plenum body, said outer surface being mountable to said chamber.

25 4. The gas distribution apparatus of Claim 1 in which said plenum body has an elongate channel formed therein, said channel partially defining said plenum.

 5. The gas distribution apparatus of Claim 1, and further comprising a baffle disposed in said plenum for uniformly distributing said gaseous substance between said nozzles.

30 6. The gas distribution apparatus of Claim 1, and further comprising a clamping device removably mounted to said plenum body, said clamping device extending across a portion of said nozzle structure to removably secure said nozzle structure to said plenum body.

7. The gas distribution apparatus of Claim 1, and further comprising a plurality of fastening configurations removably securing said nozzle structure to said plenum body.

8. The gas distribution apparatus of Claim 1 in which said nozzle structure is formed of a material selected from the group comprising ceramic materials, quartz, and metal materials.

9. The gas distribution apparatus of Claim 1 in which said plenum body is formed of a metal.

10. The gas distribution apparatus of Claim 1 in which said apparatus includes a plurality of plenums each formed for receiving a gaseous substance, said plenum body having at least one conduit coupled to each of said plenums and said nozzle structure having a plurality of nozzles coupled to each of said plenums.

11. The gas distribution apparatus of Claim 1, and further comprising a second plenum formed for receiving a second gaseous substance, said plenum body having at least one second conduit formed therein and coupled to said second plenum for delivery of a second gaseous substance to said plenum, said nozzle structure including a plurality of second nozzles coupled to said second plenum for injection of said second gaseous substance from said second plenum to said processing chamber.

12. An apparatus for injecting a gaseous substance into a processing chamber surrounded by a chamber wall comprising:

at least one plenum for receiving a gaseous substance;

a plenum body having an inner surface defining a central opening extending through said plenum body and a peripheral outer surface mountable to said chamber wall, said plenum body having at least one passageway formed therein and coupled to said plenum for delivery of said gaseous substance to said plenum; and

a nozzle structure removably mounted to said plenum body, said nozzle having a plurality of nozzles coupled to said plenum for injecting said gaseous substance into said processing chamber.

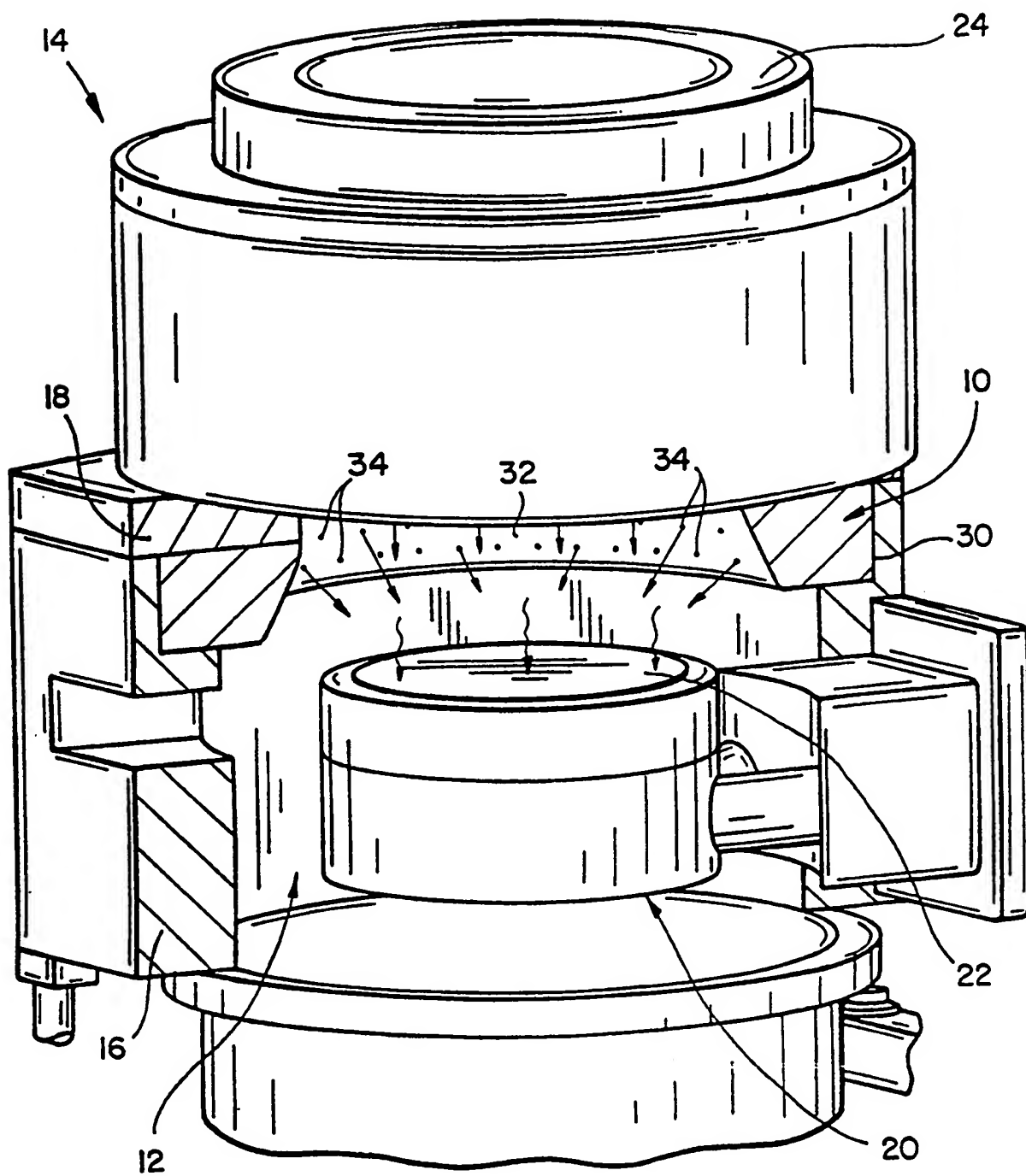
13. The apparatus of Claim 12 in which said nozzle structure is removably mounted to said inner surface of said plenum body.

5 14. The apparatus of Claim 12 in which said plenum body has a substantially annular configuration.

10 15. The apparatus of Claim 12, and further comprising at least one additional plenum formed for receiving a gaseous substance, said plenum body including at least one additional passageway coupled to said additional plenum and said nozzle structure including a plurality of additional nozzles coupled to said additional plenum for injection of said gaseous substance from said additional plenum into said processing chamber.

15 16. The apparatus of Claim 12, and further comprising a clamping device removably mounted to said plenum body, said clamping device extending across a portion of said nozzle structure to removably secure said nozzle structure to said plenum body.

17. The apparatus of Claim 12, and further comprising a plurality of fastening configurations removably securing said nozzle structure to said plenum body.

**FIG. 1**

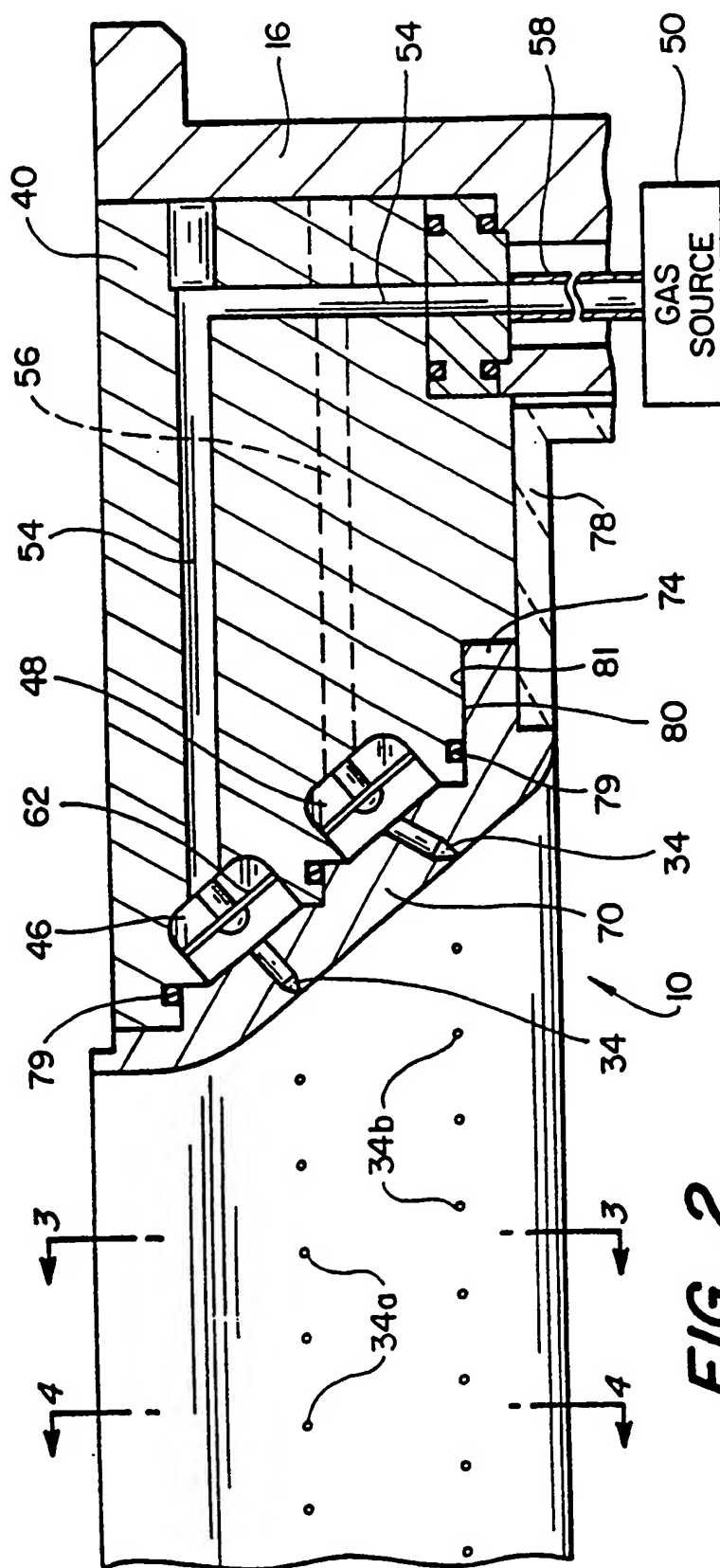
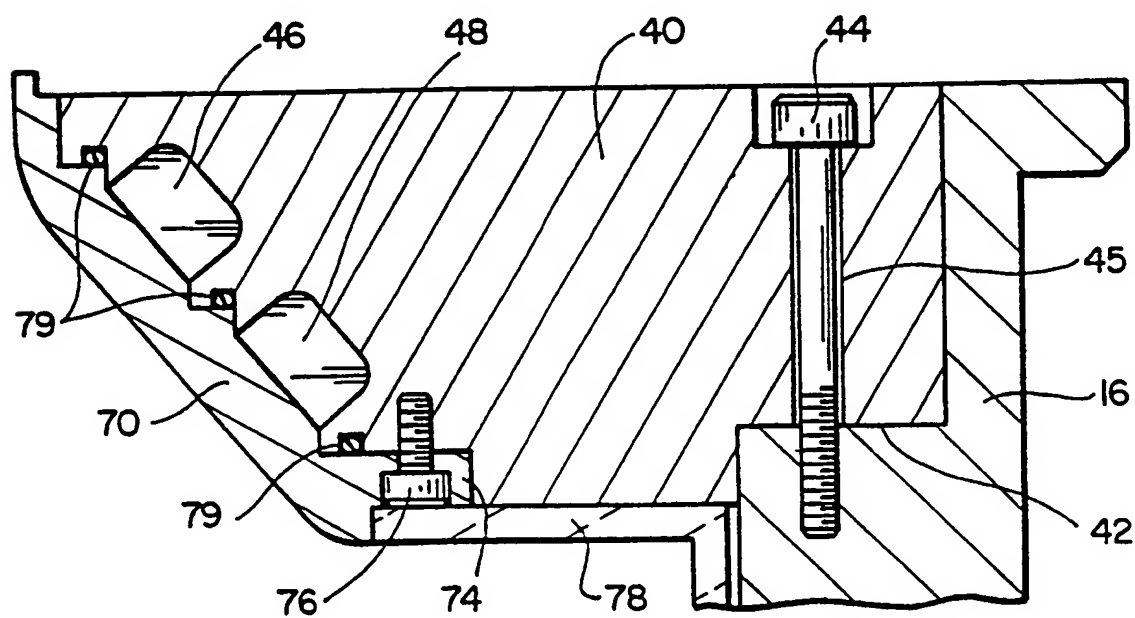
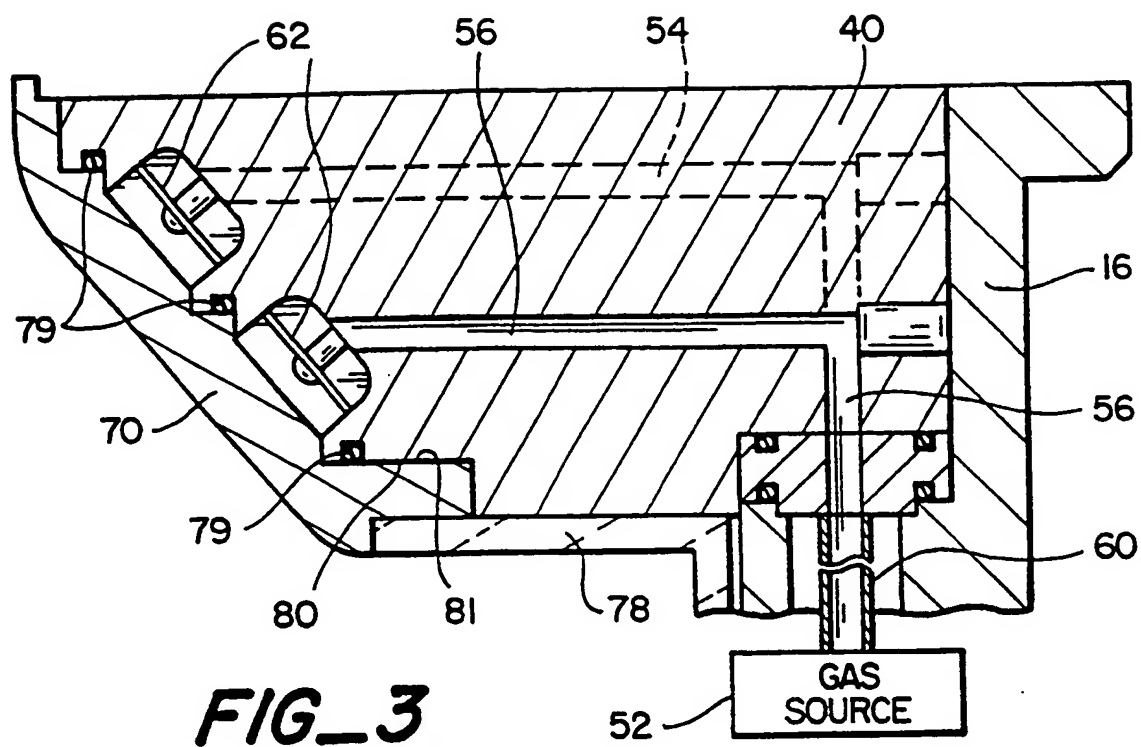
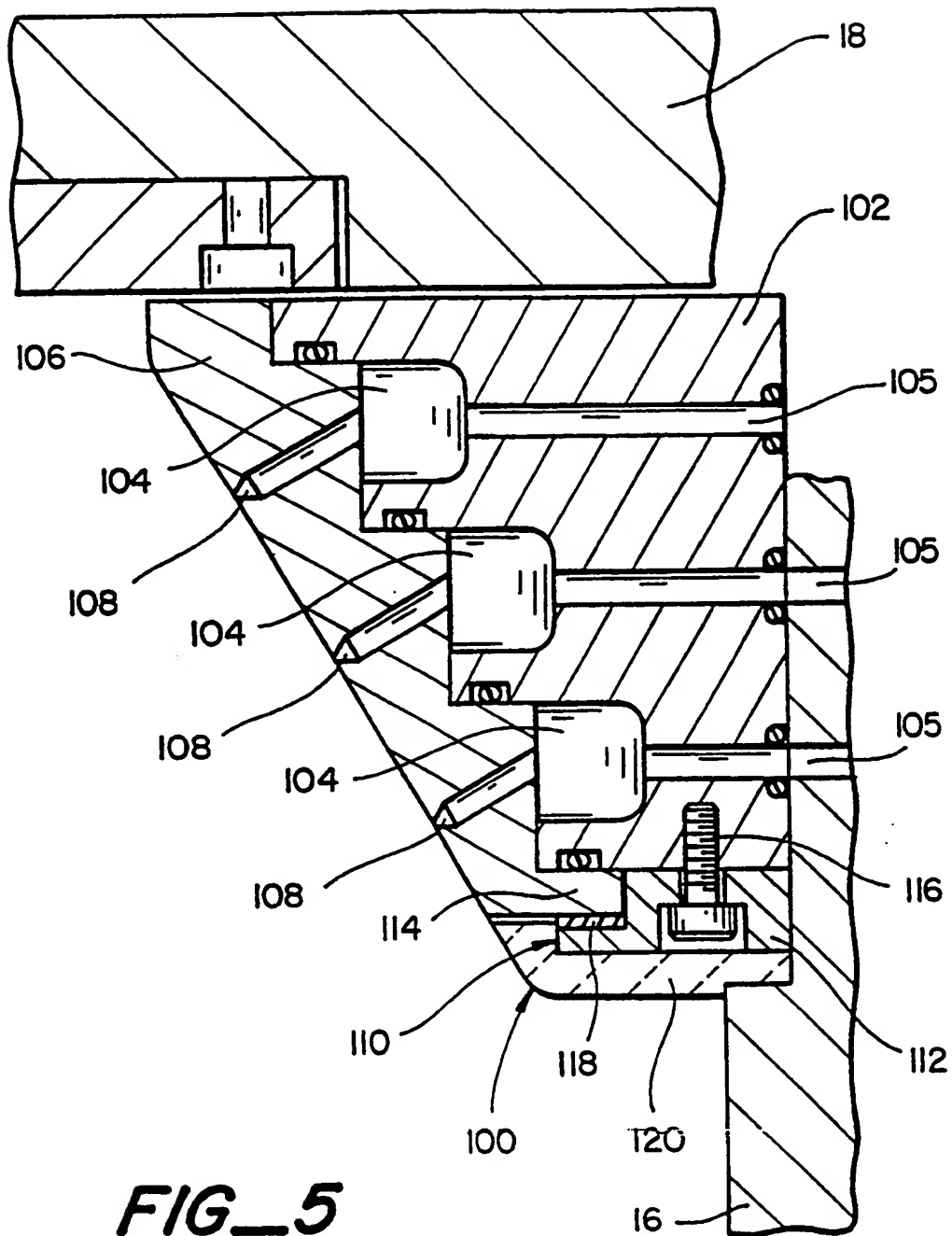


FIG-2

**FIG_4**



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US96/10657

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : C23C 16/00

US CL : 118/715, 723 ME; 204/298.07

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 118/715, 723 ME, 723 MR; 204/298.07

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

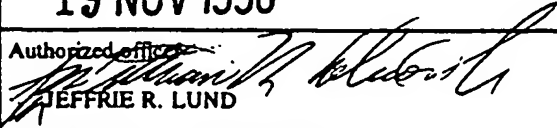
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US, 4,774,416, A (ASKARY ET AL) 27 September 1988, figure 1 and 2b, col. 4, lines 4-68.	1, 2, 6, 8 ----- 3-5, 9-16
X --- Y	JP, 2-73624, A (TSUKUNE ET AL) 13 March 1990, abstract, figures.	1, 5, 6, 8 ----- 2-4, 9-16
X --- Y	US, 4,960,488, A (LAW ET AL) 02 October 1990, col. 2, line 40 - col. 7, line 10, figures 1-3. 1, 5, 6, 8-11 ----- 12-16	

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 20 SEPTEMBER 1996	Date of mailing of the international search report 19 NOV 1996
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer:  JEFFRIE R. LUND Telephone No. (703) 308-0661

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US96/10657

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: 7 and 17
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

The phrase "a plurality of fastening configurations" is not clear in that it could be used to describe the different arrangement of the bolts or a combination of various means of fastening. Furthermore, the phrase could refer to a combination of the above categories and as a result is meaningless.
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US96/10657

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,217,559, A (MOSLEHI ET AL) 08 June 1993, col. 9, line 43 - col. 10, line 41, col. 12, line 40, figure 4.	1-6, 8-16
Y	DE 3715644, A (BACHEM ET AL) 01 December 1988, abstract, figures.	1-6, 8-16
Y	US 5,105,761, A (CHARLET ET AL) 21 April 1992, col. 5, line 16 - col. 8, line 22, figures.	1-6, 8-16
Y	US 3,381,114, A (NAKANUMA) 30 April 1968, col. 3, line 38 - col. 6, line 47, figures.	1-6, 8-16
Y	US 5,422,139, A (FISCHER) 06 June 1995, col. 6, line 25 - col. 10, line 28, figures.	1-6, 8-16
Y	US 4,834,022, A (MAHAWILI) 30 May 1989, col. 5, lines 30-59, figure 1 and 6.	1-6, 8-16
Y	JP, 59-74629, A (SAKAMOTO ET AL) 27 April 1984, abstract, figures.	1-6, 8-26
Y P	US 5,500,256, A (WATABE) 19 March 1996, col. 3, line 65 - col. 4, line 35, figures 1A, 1B, and 1C.	4, 8, 10, 11, 15
T	US 5,453,124, A (MOSLEHI ET AL) 26 September 1995, col. 3, line 24 - col. 4, line 7, figure 1.	10, 11, 15
Y	JP, 61-5515, A (ITO ET AL) 11 January 1986, abstract, figures.	10, 11, 15
Y	JP, 61-87319, A (ITO) 02 May 1986, abstract, figures.	5
Y	US 60-98629, A (KOIKE) 01 June 85, abstract, figures.	5